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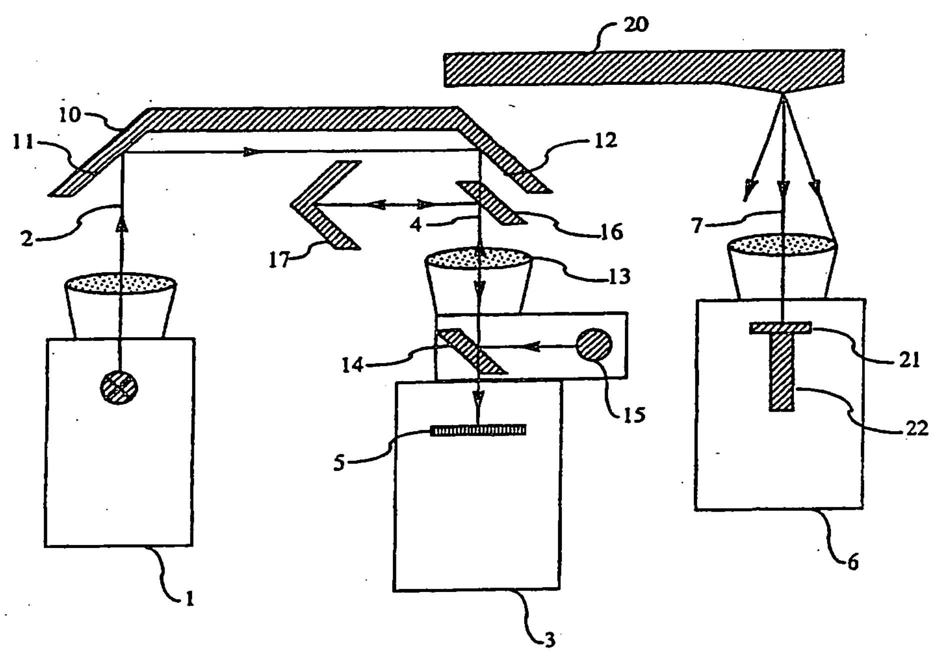
(54) Title: SYSTEM FOR VIRTUAL ALIGNING OF OPTICAL AXES

(57) Abstract



A system for virtual aligning of optical axes in a sight comprising a laser (1) having a first optical axis (2), a video camera (3) having a second optical axis (4), and an IR camera (6) having a third optical axis (7), the optical axes (3, 4, 7) being essentially parallel to each other, where a laser beam emitted from the laser (1) along its first optical axis (2) is caused by means of a prism (10) to be reflected 180° and to be projected onto a sensor (5) in the video camera (3) so that a virtual aligning of the first (2) and second (4) optical axes can be executed by image processing, where a light source (15) is made send a light beam to a beam splitter (14) located in the second optical axis (4), whereby the light beam is deflected out through the video camera's (3) objective (13) and is reflected by a reflector into the video camera's (3) sensor, (5) permitting a virtual aligning of the light beam in relation to the first optical axis (2) to be effected, and where the reflector and prism (10) are moved aside and a mirror (20) is placed in the path of both the video camera's (3) optical axis (4) and the IR' camera's optical axis (7) so that the light beam from the light source (15) is reflected by the mirror (20) into the video camera's (3) sensor (5), and the IR camera's (6) IR beam is reflected by the mirror (20) whereby, since the geometry of the mirror (20) is known, a virtual alignment of the IR camera's (6) optical axis (7) with the light beam and thus with the first optical axis (2) is performed by mean of image processing.

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SYSTEM FOR VIRTUAL ALIGNING OF OPTICAL AXES

TECHNICAL FIELD

The invention relates to a method and a device for virtual aligning of optical axes in a laser in the form of a laser pointer and light-sensitive sensors, as well as both a video camera and a IR camera in a sight.

STATE OF THE ART

When tracking a target, in particular moving targets, using sighting equipment on a weapon it is common today to employ a technique in which the target is pointed out by a laser beam emitted from a laser in the sight. In order to be able to position the laser beam on the target the sight has to be equipped with optical sights, which allows the sight operator to see and follow the target. Optical sights of this type can be comprised of ordinary optical telescope, video cameras, or cameras for detecting infrared light, so called IR cameras. If an operator, with the aid of a video camera or a IR camera, aims at a target by, for example, ensuring that the cross hairs in the optical sight fall on the target, this does not mean that the sight's laser beam also hits the target, as the optical axes of the optical sight may not coincide with the optical axis of the laser. Thus it is of great importance that the said optical axes are made to coincide with the laser's optical axis, a procedure designated here as aligning.

An example of a device for aligning of optical axes in a sight as above is described in patent document US 4902128. In the said document, an ordinary optical telescope is used for aligning in daylight. The document is cited here purely as an example of an known technique.

In a device for aligning as described above, one of the difficulties is that aligning the optical axes of the different units has to be arranged in such a way that it takes into account the fact that the wavelength of light for the various instruments, laser and IR camera for example, are different.

DESCRIPTION OF THE INVENTION

According to an aspect of the present invention a method for virtual aligning of optical axes in a sight as specified in the independent methods claim 1 is presented.

According to a further aspect of the present invention a device for virtual aligning of optical axes in a sight as specified in the independent device claim is presented.

The invention relates to aligning of a video camera and IR camera to a laser pointer with a high degree of accuracy. The equipment is essentially self-calibrating during the aligning procedure and therefore the tolerance levels required for included components can be set relatively low. It is important that the components used in the device are rigid and measured individually, so that known errors in measuring can be compensated for in the subsequent signal processing.

The equipment according to the invention takes up a small volume and is adaptable to different sensor combinations, and positioning.

DESCRIPTION OF DRAWINGS

Fig. 1 shows schematically the components and beam paths of the aligning device.

Fig. 2 depicts the beam path for the procedure of aligning the video camera in relation to the laser pointer.

Fig. 3 depicts the beam path for the procedure of aligning the light source in relation to the laser pointer.

Fig. 4 depicts the beam path for the procedure of aligning the IR camera in relation to the laser pointer.

DESCRIPTION OF PREFERRED EMBODIMENTS

A number of preferred embodiments are described below with the aid of the drawings.

The sight contains a laser pointer 1 which can emit a laser beam along a first optical axis 2 towards a target. In order for an operator to aim at the target in the daytime in daylight and under good light conditions, the sight uses a video camera 3, the optics of which are arranged with a second optical axis 4, along said second optical axis visible light falls on the video camera and can be detected in the video camera's sensor 5. In the example the sensor 5 is comprised of a CCD chip. Alternatively, to be able to aim at the target, the operator can use a heat-sensitive camera, an IR camera 6, which is used by the operator when aiming at the target in the dark or during periods of poor light conditions. The optics in the IR camera 6 are arranged along and centred along a third axis optical axis 7. Both the video camera and IR camera can generate image information in the form of an electrical signal. The image is viewed by the operator on other equipment, for example a monitor, by using this electrical signal. Before presentation of the image it is possible, in other equipment such as image processing equipment, to manipulate the electrical signal in order to change the displayed image in the desired way. The three optical axes run essentially parallel to each other, but a certain amount of non-linearity may occur. If the three optical axes 2, 4, 7 run parallel to each other, the operator can by means of cross hairs in the optical axis of any of the cameras ensure that the optical axis of each camera is positioned on the target by rotating the respective used cameras to the target which is shown as an image in the camera. If the said non-linearity occurs this method does not work. The purpose of the method and the device according to the invention is to align said optical axes virtually, so that the laser beam of the laser pointer 1 hits at a certain distance the target surface which is represented by the image of the target surface displayed in any of the cameras 3, 6. This method is termed aligning. By determining the deviation between the first optical axis 2 and the video camera's optical axis, the second optical axis 4, a first calibration signal, which is a measure of measured deviation, is obtained. This first calibration signal is memorized and sent to an image processor which calibrates the electrical signal containing the video camera's image information using the first calibration signal, so that the image information which is sent to the monitor is manipulated

in such a way that the image generated in the video camera is displaced laterally in relation to the measured deviation, whereby a virtual aligning of the video camera in relation to the laser pointer is achieved. This means that the operator aims at a point where they believe the target to be, while the image in the monitor is displaced in relation to the measured deviation in such a way that on aiming the video camera at the target the laser beam of the laser pointer which is aligned with the video camera falls on the target. The described technique of image processing as described for manipulating signals between a video camera and a monitor is well known and is not described further here.

In the device which embodies the sight a hollow eaves prism 10 can be interposed in the path of the laser beam as illustrated in fig. 1, when aligning is to be performed. The laser beam hits a first inner 11 tilted reflecting surface in the hollow eaves prism 10, is reflected 90°, after which it hits a second inner 12 tilted reflecting surface in the hollow eaves prism 10. The laser beam is reflected back in this way so that it passes through the video camera's 3 lens 13, passes a beam splitter 14, to be thereafter detected by the video camera's sensor 5, i.e. the CCD chip.

A concentrated light source 15 for calibrating at a wavelength that is detectable by the video camera is integrated internally in the video camera 3 between the sensor 5 and the video camera's 3 lens 13. According to the example the light source 15 is arranged so that it emits a light beam perpendicular to and towards the side of the beam splitter 14 which is positioned in the path of the second optical axis 4. The light beam is reflected 90° and through the lens 13 of the video camera. A reflector comprising a mirror 16 and a hollow cube-corner prism 17 is arranged in the path of the light beam, when aligning is being performed, along the second optical axis 4 so that the light beam hits the tilted mirror 16 and reflects the light beam 90° laterally. There the light beam hits the cube-corner prism 17, so that the beam is reflected without any deviation in angle back to the tilted mirror 16, whereby the light beam is once again reflected 90° and follows the second optical axis 4 into the lens 13 of the video camera, passes through the beam splitter 14 without deflection to be finally detected by the sensor 5 of the video camera. The cube-corner prism 17 is geometrically stable with both temperature and time. The positioning of the reflector comprising the mirror 16 and the prism 17 is not

critical when performing the alignment.

When performing the alignment, a double mirror 20 can be rotated into the line of sight of both the video camera 3 and the IR camera 6, i.e. so that it falls in the path of both the second 4 optical axis and the third 7 optical axis, in addition to covering the greater part of their focal apertures. On swinging in the double mirror in the said manner the reflector comprising the mirror 16 and the prism 17, and the prism 10 are not in use and removed from the line of sight. The double mirror 20 is designed in such a way that its surface is planar in the light beam's path in front of the video camera 3, which means that the double mirror subsequently reflects the light beam from the concentrated light source 15 back into the video camera. In the line of sight in front of the IR camera, i.e. in the optical axis of the IR camera, the double mirror is roof-shaped so that, separated by a little space, two mirror images of the in-built heat radiator 21 are produced and captured by the IR camera 6. The double mirror 20 is geometrically stable over the relevant temperatures and with time.

The procedure for aligning consists of a number of steps as follows:

As shown in fig. 1 the eaves prism 10 is interposed in the path of the beam in front of the laser pointer 1, so that the laser beam emitted from this along the first optical axis 2 will hit the first inner tilted reflecting surface 11 and be reflected 90° laterally towards the second tilted inner reflecting surface 12 in the hollow eaves prism 10. In this way the laser beam will be reflected again by 90°, and thus will have been reflected 180° in total. The eaves prism 10 is adapted and oriented to the equipment comprising the sight so that the reflected laser beam is centred around the second optical axis 4 and thus passes through the video camera's 3 lens 13, after which the laser beam hits the video camera's sensor 5. By externally executed mean formation and tracing of the energy centre of the laser beam, where it falls on the CCD chip which constitutes the video camera's sensor 5, any deviation of the laser beam in relation to the video camera's own optical axis, the second optical axis 4, can be detected. In this way it is possible to generate the above mentioned first calibration signal related to the deviation, and to memorize this deviation electronically, and compensate for the said deviation when using the sight by image processing as described above, which involves aligning the video

camera virtually with the laser pointer's 1 first optical axis 2.

In a subsequent step the eaves prism 10 is moved aside. It can be mounted on a hinge arrangement, so that it is swung into the path of the beam as described, or is swung aside when not in use. The reflector comprising the mirror 16 and the cube-corner prism 17 is slid into the beam path of the video camera 3, after which the light source 15 is activated. See fig. 3. The light beam from the concentrated light source 15 is emitted from the video camera 3 and and reflected back into the video camera 3 to its sensor 5, as described above. By externally executed mean formation and tracing of the energy centre of the laser beam, where it falls on the CCD chip which constitutes the video camera's sensor 5, any deviation of the laser beam in relation to the video camera's own optical axis, the second optical axis 4, can be detected. In this way it is possible to memorize this deviation electronically. Since a memorizing of the deviation of the second optical axis 4 from the first optical axis 2 has already been performed, the deviation of the light beam, from the light source 15, from the first optical axis can now be determined. This is done by creating a second calibration signal which is a measure of the light beam's deviation from the first optical axis 2.

During a subsequent step in the procedure the double mirror 20 is interposed in the path of the beam of both the video camera 3 and the IR camera 6. Naturally, neither the eaves prism 10 nor the reflector comprising the mirror 16 and the prism 17 are used here, both of which are removed from the beam paths. See fig. 4. The light beam from the concentrated light source 15 is reflected by the planar part of the double mirror 20 back into the video camera to its sensor 5. By externally executed mean formation and tracing of the energy centre of the laser beam, where it falls on the CCD chip which constitutes the video camera's sensor 5, the double mirror 20 can now be aligned virtually in relation to the first optical axis 2, i.e. to the laser pointer 1. This is effected by formation of a third calibration signal, the value of which is memorized, and which is a measure of the orientation of the double mirror's 20 position in relation to the first optical axis 2. Since the internal orientation and alignment of both the planar part and the roof-shaped part of the double mirror 20 in relation to each other are known, the roof-shaped part of the double mirror 20 is aligned virtually in relation to the laser pointer 1.

In the final step the IR camera is aligned in relation to the laser pointer 1. This is achieved in a first step by means of the so called Narcissus effect, in other words the IR camera itself finds its mirror image in the roof-shaped part of the double mirror 20. This is attained by the IR camera 6 producing a thermal mirror image from the reflections in the double mirror 20 of its cryogenic cooled detector. Since the roof-shaped part of the double mirror 20 produces a double mirror image, with a space between, of the cooled detector, a subsequent image processing of the IR camera's video signal can localize the centre of the IR detector with a high degree of accuracy despite the fact that the IR scanner is a "scanning sensor". A fourth calibration signal, which is used as a value of the IR camera's optical axis, the third optical axis 7, is based on the detected position of the detector's centre on reflection in the double mirror 20.

On using the IR camera as a target finder in the sight the IR camera's optical axis can now be aligned virtually with the laser pointer's optical axis by weighing together the first, second, third and fourth calibration signals, which together yield a measure of the deviation of the IR camera's optical axis 7 from the laser pointer's optical axis 1. As mentioned above, these calibration signals have been memorized during alignment of the sight and can now be used so that the image information that is sent to a viewing monitor from the IR camera 6 is manipulated in such a way that the image that is generated in the IR camera is displaced laterally in relation to the measured deviation, whereby a virtual alignment of the IR camera 6 in relation to the laser pointer 1 is attained. This means that the operator of the IR camera 6 aims at a point where they believe the target to be, but the image is displaced in the monitor in relation to the measured deviation in such a way that on directing the IR camera 6 at the target, the laser pointer's 1 laser beam which is aligned with the video camera falls on the target. The described method of image processing for manipulation of the signal between a camera and a monitor is a known technique and is not described further here.

CLAIMS

1. Method for virtual aligning of optical axes (2, 4, 7) in a sight comprising a laser (1) having a first optical axis (2), a video camera (3) having a second optical axis (4), and a IR camera (6) having a third optical axis (7), where the first (2), second (4) and third (7) optical axes are essentially parallel to each other, characterized in that the method includes the steps:

a) a laser beam emitted from the laser (1) along its first optical axis (2) is caused by means of a prism (10) to be reflected 180° and to be projected onto a sensor (5) in the video camera (3),

b) a detection of deviation between the first (2) and the second (4) optical axes is executed,

c) a light source (15) is made send a light beam to a beam splitter (14) located in the second optical axis (4), so that the light beam is deflected through the video camera's (3) objective (13) and is reflected by a reflector (16, 17) into the video camera's (3) sensor (5),

d) a detection of deviation between the light beam and the first optical axis (2) is executed,

e) the reflector (16, 17) and the prism (10) is moved aside and a mirror (20) is placed in the path of the video camera's (3) optical axis (4) and the IR camera's optical axis (7), so that the light beam from the light source (15) is reflected by the mirror (20) into the video camera's (3) sensor (5),

f) the IR camera's (6) IR beam is reflected by the mirror (20),

g) since the geometry of the mirror (20) is known the deviation between the IR camera's (6) optical axis (7) and the light beam is detected,

h) the detected deviation is used in image processing for a virtual alignment of the video camera (3) and the IR camera (6) with the laser pointer (1).

2. Method as in claim 1, characterized in that the virtual aligning of the first optical axis (2) and the second optical axis (4) is executed as follows:

- a prism (10) is interposed in the path of the beam in front of the laser pointer (1), whereby the laser beam emitted from the laser pointer along the first optical axis (2) will be projected onto a first inner tilted reflecting surface (11) and be reflected 90° laterally towards a second tilted inner reflecting surface (12) in the prism (10), so that the laser beam is reflected a further 90° and thus is deflected 180° in total,

- the prism (10) is arranged so that the reflected laser beam is centred around the second optical axis (4) and passes through the video camera's (3) lens (13), after which the laser beam hits the video camera's sensor (5),

- the deviation of the laser beam in relation to the video camera's (3) own optical axis, the second optical axis (4), is detected and memorized, and

- the detected and memorized deviation is used in image processing to calibrate the video camera's (3) image signal for compensation for the deviation between the first and the second optical axes.

3. Method as in claim 2, characterized in that alignment of the light beam in relation to the first optical axis (2) is effected as follows:

- the prism is moved aside,

- the reflector comprising a tilted mirror (16) and a cube-corner prism (17) is interposed in the beam path of the video camera (3),

- the light source (15) is activated, whereby the light beam from the light source (15) is emitted from the video camera (3) and reflected by the tilted mirror (16) and the cube-corner prism (17) back into the video camera (3) to its sensor (5),

- the deviation of the light beam in relation to the video camera's (3) own optical axis, the second optical axis (4), is detected and measured,

- the deviation of the light beam in relation to the first optical axis (2) produces a second calibration signal, which is memorized.

4. Method as in claim 3, characterized in that alignment of the IR camera's (6) optical axis (7) with the light beam and thus to the first optical axis (2) is effected as follows:

- from the planar part of the mirror (20), which comprises both a planar part and a roof-shaped part, the light beam from the light source (15) is reflected back into the video camera's (3) sensor (5),

- the deviation of the reflected light beam in relation to the video camera's (3) own optical axis, the second optical axis (4), is detected and measured, whereby the mirror's (20) alignment in relation to the first optical axis (2) can be memorized as a third calibration signal,

- the roof-shaped part of the mirror(20) reflects the IR light beam from the IR camera (6) back into the IR camera's (6) detector, whereby orientation of the IR camera's optical axis (7) can be determined and is represented by a fourth calibration signal, and

- the generated and memorized calibration signals are used in image processing to calibrate the IR camera's (6) image signal for compensation for the deviation between the IR camera's (6) optical axis (7) and the first optical axes (2).

5. Device for virtual aligning of optical axes (2, 4, 7) in a sight comprising a laser (1) having a first optical axis (2), a video camera (3) having a second optical axis (4), and a IR camera (6) having a third optical axis (7), where the first (2), second (4) and third (7) optical axes are essentially parallel to each other, characterized in that

- a first reflecting means (10) is arranged to be interposed in a laser beam emitted from the laser (1), so that the laser beam is reflected back into the video camera (3) to virtually align/ for virtual aligning of the video camera (3) with the first optical axis (2) by means of image processing,

- a light source is arranged to emit a light beam through the video camera's (3) lens (15) and hit a second reflecting means (16, 17) which is interposed in the path of the light beam, so that the light beam is reflected in to the video camera (3) for virtual aligning of the light beam in relation to the first optical axis (2),

- a third reflecting means (20) is arranged to be placed in the beam path of both the video camera (3) and the IR camera (6), so that the light beam from the light source (15) is reflected into the video camera (3) and so that the IR camera's light (6) is reflected into the IR camera for virtual aligning of the IR camera (6) in relation to the first optical axis (2) by means of image processing.

6. Device as in claim 5, characterized in that the first reflecting means (10) comprises a hollow eaves prism having a first inner (11) tilted reflecting surface which deflects the laser beam 90° and a second inner (12) tilted reflecting surface which deflects the laser beam a further 90° .

7. Device as in claim 5, characterized in that the light source is concentrated and arranged inside the video camera (3) so that light is projected onto a beam splitter (14) positioned on the second optical axis (4).

8. Device as in claim 7, characterized in that the light source (15) emits light of such wavelength that can be detected by a sensor (5) in the video camera (3).

9. Device as in claim 7, characterized in that the second reflector comprises a tilted mirror (16) and a hollow cube-corner prism (17), where the mirror (16) deflects the light beam 90° towards the hollow cube-corner prism (17), whereby the light beam is reflected 180° back to the mirror (16), where the light beam is once again reflected 90° into the video camera's (3) sensor (5).

10. Device as in claim 5, characterized in that the third reflecting means (20) comprises a double mirror including both a planar mirror component which reflects the light beam from the light source (15), in addition to a roof-shaped mirror component which reflects the light emitted from the IR camera (6).

11. Device as in claim 10, characterized in that the roof-shaped part of the double mirror (20) is designed to generate two mirror images of a heat radiator in the IR camera (6).

Fig. 1

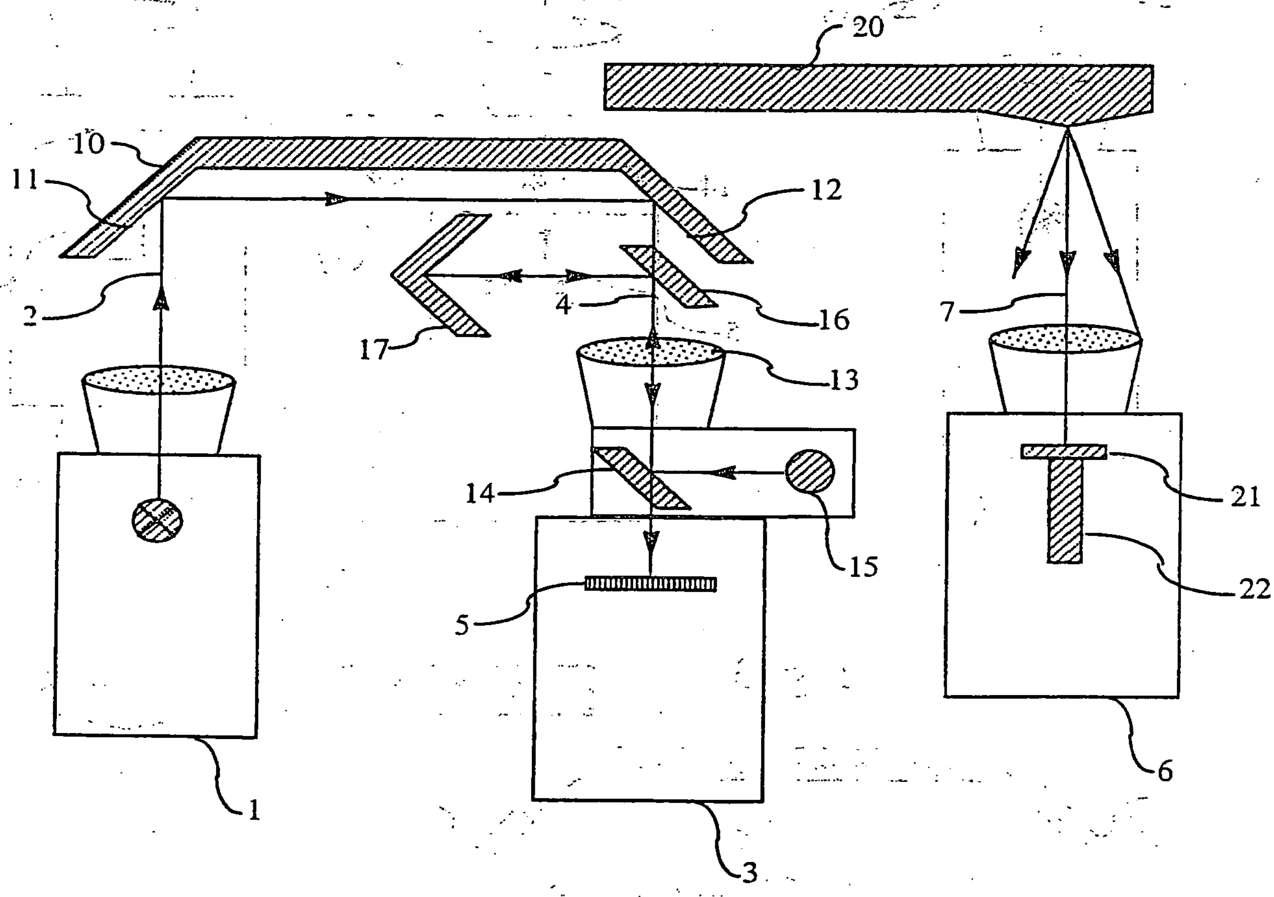

Fig. 2

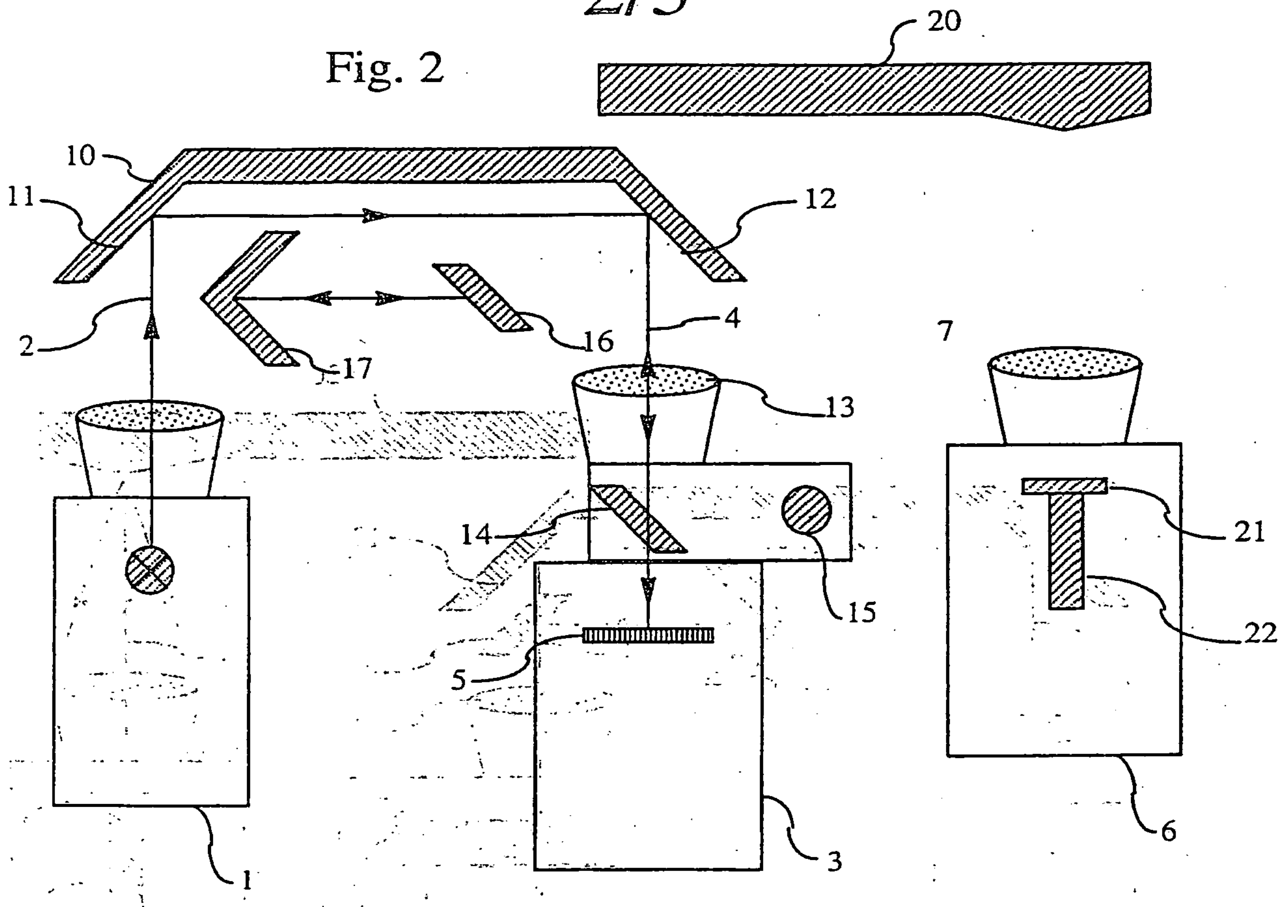
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Fig. 3

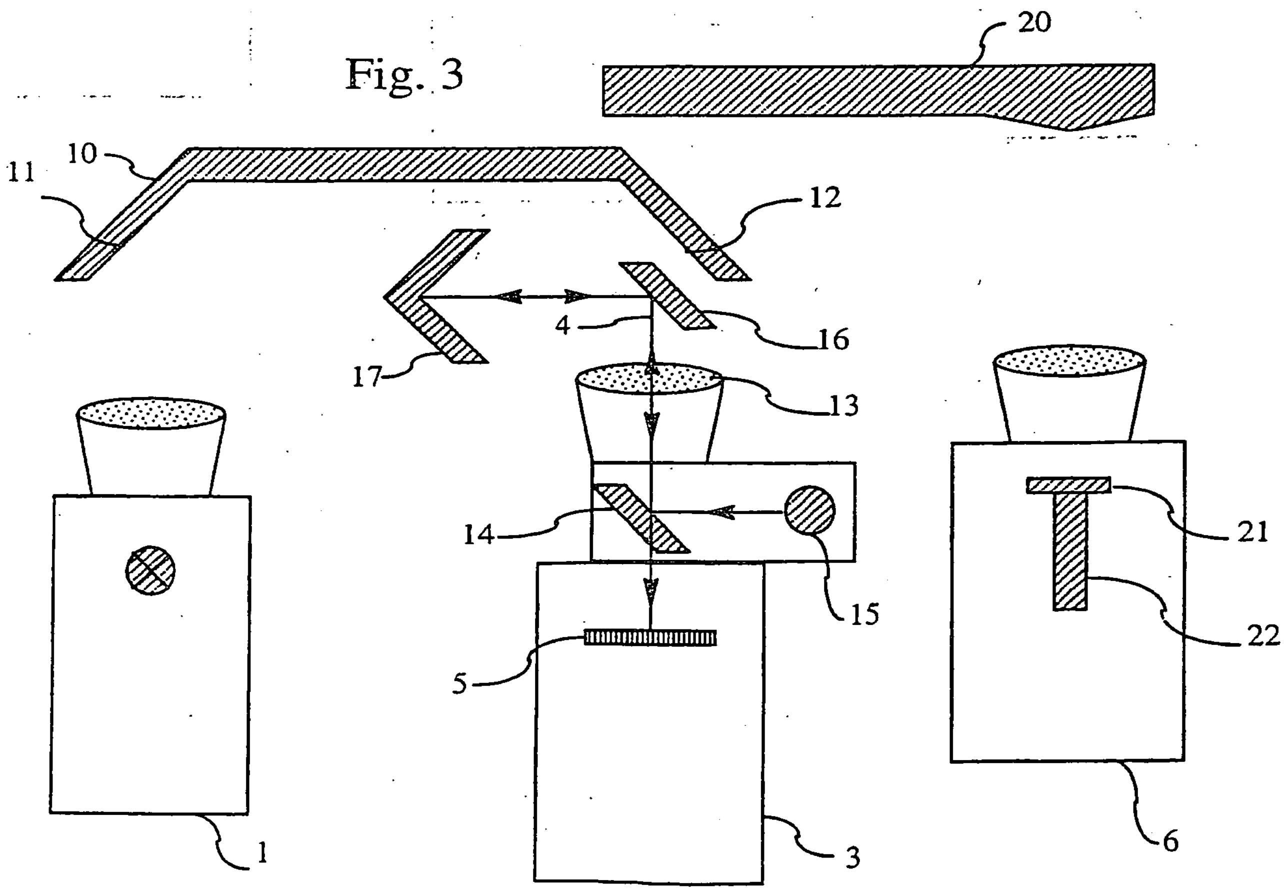
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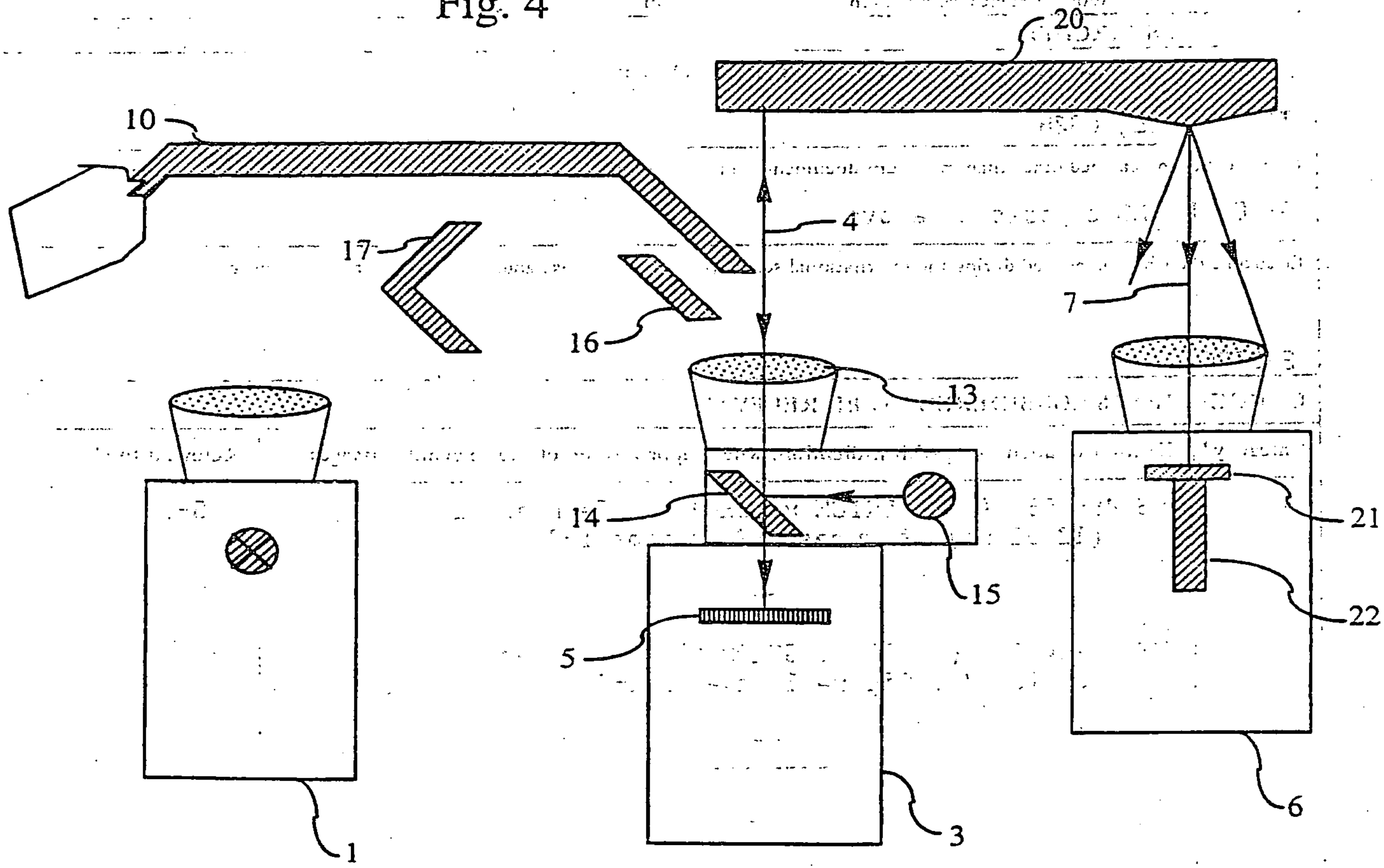
Fig. 4



INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/01911

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: G02B 23/02, G02B 23/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: G01B, G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPODOC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4991959 A (RODERICH RUEGER), 12 February 1991 (12.02.91), figures 1-2, claims 1-3 --	5-7
A	US 5675412 A (PETER R. SOLOMON), 7 October 1997 (07.10.97), figure 1, claims 1-3 -- --------	5,6

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4991959 A	12/02/91	CA 1322117 A	14/09/93
		DE 3739698 A	08/06/89
		FR 2623636 A,B	26/05/89
		GB 2212939 A,B	02/08/89
US 5675412 A	07/10/97	AU 1121297 A	11/06/97
		EP 0862725 A	09/09/98
		WO 9719319 A	29/05/97